Pollinator-Friendly Cover Cropping

FOR VEGETABLE PRODUCERS IN THE UPPER MIDWEST

Left to right: Diverse cover crop mix in Minnesota[1], mud dauber wasp on buckwheat[2], bumble bee on phacelia[3]. (Photos: Sarah Foltz Jordan / Xerces Society[1,2]; Naomy Candelaria[3].)

Value of Cover Crops to Beneficial Insects

Cover crops have many traditional uses on farms, ranging from preventing erosion and improving soil health to suppressing weeds and breaking pest cycles. In addition, with appropriate plant selection and proper management, flowering cover crops can support bees and other pollinators by providing pollen and nectar resources that improve insect health and reproductive potential. Similarly, the forage and shelter provided by cover crops can help support a variety of beneficial insects important in natural pest control, such as parasitoid and predaceous wasps, ground beetles, hoverflies, and more. This bulletin will help you use cover crops to attract and support pollinators and other beneficial insects on your farm, while also addressing other resource concerns (see **Table 1—Select Blooming Cover Crops**).

Pollinator Cover-Cropping in Vegetable Systems

Diversified vegetable growers generally manage complex crop rotations, often including dozens of crops from ten or more different plant families, each with its own fertility needs, planting, and harvest times. In the Upper Midwest, growers have the added challenge of fitting these crops into a very short growing season, sometimes as narrow as a few months. Although there are many benefits to adding cover crops to these vegetable rotations, it can be challenging to find a window of opportunity to work with, especially when pollinator goals require the timeframe to be long enough to ensure that the cover not only establishes, but reaches the point of flowering and supporting pollinators. Here, we highlight key opportunities for adding blooming cover crops to vegetable cropping systems in this region (Figure 1).

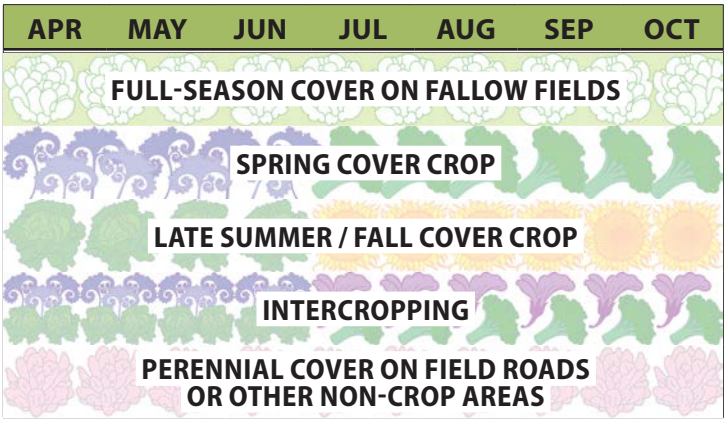

Figure 1—Cover crop options for pollinators in vegetable systems in the Upper Midwest.

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Opportunities for Incorporating Flowering Cover Crops Into Vegetable Systems

Figure 2—This field at Agua Gorda farm in Long Prairie, MN shows full-season cover planted on a temporarily fallow field. Designed to support pollinators, the mix included oats, field peas, medium red clover, crimson clover, buckwheat, and phacelia. Farmer Javier Garcia was impressed with the pollinator activity in the plot, and especially appreciated the time saved not having to do repeat cultivation on the fallow fields to manage weeds. (Photos: Sarah Foltz Jordan / Xerces Society.)

#1 **Full-season cover on fallow fields that are not in vegetable production for one or more growing seasons.** With minimal planning and a lot of reward, these areas can be planted to cover crops that will hold soil in place, build soil fertility, boost populations of beneficial insects, and suppress weeds during the fallow period. Cover crops should be selected to fill the space over the entire growing season, either by planting single species in succession (e.g., cool season ➛ warm season ➛ cool season), or a multispecies mix including a blend of cool- and warm-season species. Some full-season covers can also be used for chicken pasture or livestock grazing, particularly near the end of the season when damage to the planting is not a concern (and may even be a welcome method for termination).

#2 **Partial-season cover to fill production gaps (short windows of time when the soil is bare between crops).** Cover crop opportunities may occur 1) during the spring/early summer, to fill a gap before later-season vegetable crops are planted or 2) during the summer/fall, after spring vegetable crops are harvested. Cool-season cover crop options can be seeded in early spring and terminated before planting of vegetables such as fall broccoli or greens, while warm-season cover crops can be seeded after the harvest of a spring vegetable like lettuce, radishes, or peas. Additionally, if early- and late-season crops are stacked in one area in the same growing season, there *may* be a very short mid-season gap between the two crops that could sustain cover cropping. Note, however, University of MN research has found that it can be difficult in this region to achieve bloom of a mid-season cover crop *and* have enough time on either side of the cover crop window for two successful cash crops.

Figure 3—Buckwheat and sorghum Sudangrass seeded at Sogn Valley Farm in Cannon Falls, MN. These two fast-growing species were planted to suppress weeds and provide biomass after a summer-harvested vegetable crop. The buckwheat also provided a brief but abundant foraging resource for pollinators and beneficial insects. According to farmer Dana Jokela, there are several cover crop options for seeding in late summer (following crops like cucumber, zucchini, and summer Brassicas). (Photos: Karin Jokela / Xerces Society.)

Figure 4—Left: Crimson clover intercropping with leeks at Uproot Farm in Princeton, MN. Seeding took place at the final cultivation of the already-established leek crop. The clover was broadcast seeded on top of the soil, and then a pass was made with cultivation equipment to bury the seed and manage weeds. According to farmer Sarah Woutat (right), this method is consistently successful both for leeks and fall brassicas, but it is important to catch the crop at the perfect stage when it is still young enough to be cultivated, and small enough to not shade out the clover, in the case of brassicas. Also, adequate soil moisture is important. For this farm in central MN, even seeding as late as August 1st can achieve dense bloom of the clover. (Photos: Sarah Woutat [left]; Sarah Foltz Jordan / Xerces Society [right].)

#3 **Intercropping** (growing flowering cover crops in close proximity to vegetable crops, over the same or overlapping periods of time). Common scenarios include:

- Planting low-growing or quick-growing cover crop with a taller or widely-spaced or slow-growing vegetable crop, either at the time the vegetable crop is planted, or after the vegetable is established.
- Planting a cover crop in the alleys between vegetable beds

In addition to thoughtful species selection, timing is key for successful intercropping. The vegetable crop must be vigorous and established enough to tolerate some competition from the cover crop, but small enough to cultivate between the rows and not shade out the cover. Careful timing is also necessary if the goal is for the cover crop to reach flowering to supply food for pollinators.

#4 **Perennial covers on field roads or other non-crop areas.** Permanent or temporary field roads, borders, or other marginal areas offer an excellent opportunity to provide pollinator forage. If the area receives some amount of disturbance (e.g., parking areas or places where equipment is stored) choose cover crop species that tolerate mowing and foot/vehicle traffic. In situations where permanent habitat is desired, native perennial mixes could also be considered.

Figure 5—Field road at Sogn Valley Farm seeded to white Dutch clover, at a seeding rate of about 10 lb/acre. This short-lived perennial tolerates traffic, responds well to mowing, and blooms prolifically, attracting honey bees and other insects. Farmer Dana Jokela reports that these plantings typically perform well for about 5 years before floral density declines and weeds begin to creep in, indicating the need to cultivate and re-seed. (Photo: Karin Jokela / Xerces Society.)

Species Selection

There are a variety of commercially-available cover crop species that provide foraging resources for pollinators (Table 1). As with any planting endeavor, what you grow will depend on your goals, location, soil type, cropping system, budget, and other factors. Since some cover crops thrive in cooler seasons and some in warmer, your plant selection will be further narrowed by the planting window you are working within, as well as your plan for terminating the cover crop.

Table 1—Select Blooming Cover Crops

These cover crops have been selected because they provide pollinator value in the Upper Midwest[1].

	CULTIVATION							OBJECTIVES[6]							
SPECIES	↻	PLANTING TIME[2]	FROST TOLERANT	SEEDING RATE[3]	SEEDING DEPTH[4]	AVG. DAYS TO BLOOM	GAPS[5]	WEED MGMT.	FORAGE	N SCAVENGER	N SOURCE	EROSION CTRL.	FORAGE	COMP.	NEM. MGMT[7]
Flowering cover crops with high insect visitation (excluding legumes and brassicas). [FAMILIES are in brackets]															
Buckwheat (*Fagopyrum esculentum*) [Polygonaceae]	A	E M	—	75–90	1"	28–40	E M I	✔	✔	✔					
Flax (*Linum* spp.) [Linaceae]	A P	E M	✔	45–50	0.75–1.5"	45–60	E M F O I		✔						
Phacelia (*Phacelia tanacetifolia*) [Boraginaceae]	A	E M	✔	12–15	Surface	56–64	E M I		✔				✔		
Sunflower (*Helianthus* spp.) [Asteraceae]	A	E M	—	7–10	0.5"	60–80	F M	✔	✔	✔			✔	✔	
LEGUMES [FAMILY: Fabaceae] provide nitrogen (N) to the system, especially in nutrient-poor soils. Once natural soil-borne other factors; some winter-kill while others will overwinter. Balancing pollinator goals with soil health goals may be															
Alfalfa (*Medicago sativa*)	P	E M F	✔	18–20	0.25"	70–90	F O P	✔	✔	✔	✔		✔	✔	
Berseem clover (*Trifolium alexandrinum*)	A	E M	✔	10–20	0.25"	60–80	E M I	✔	✔		✔		✔		
Cowpea (*Vigna unguiculata*)	A	M	—	75–90	1"	40–48	M		✔		✔		✔	✔	
Crimson clover (*Trifolium incarnatum*)	A	E M	✔	15–25	0.25"	60–80	F E M I		✔		✔		✔		
Hairy vetch (*Vicia villosa*)	W	F	✔	20–25	0.5–1.5"	80–90	O		✔		✔		✔		
Partridge pea (*Chamaecrista fasciculata*)	A	E	—	15–20	0.25–0.75"	70–90	F		✔		✔		✔		
Red clover (*Trifolium pratense*)	P	E	✔	25–35	0.25"	60–70†	F O I P	✔	✔		✔	✔	✔		
Sunn hemp (*Crotalaria juncea*)	A	E	—	30–40	0.75"	50–70	F	✔	✔		✔		✔		
White clover (*Trifolium repens*)	P	E	✔	10–15	0.25"	60–90†	F O I P	✔	✔		✔	✔	✔		
BRASSICAS [FAMILY: Brassicaceae] are N scavengers that thrive in disturbed areas with high levels of free nutrients. Often deep- beetles and plant pathogens can be a concern in some vegetable cropping systems.															
Canola/ rapeseed (*Brassica napus*)	A	E M F	✔	5–10	0.5"	50–60	E M	✔	✔	✔		✔	✔	✔	✔
Forage/ oilseed radish[9]	A	E M F	—	8–15	0.25"	40–70	E M	✔	✔	✔		✔	✔	✔	✔
Mustards (*Brassica* spp., *Sinapis* spp.)	A	E M F	✔	6–20	0.5"	50–60	E M	✔	✔	✔		✔	✔	✔	✔

Notes:

1. Species that can be problematic as invasives, such as sweet clovers and non-native lupin, were omitted from this table
2. Planting time—Early, Midsummer, Fall
3. Suggested seeding rate—pounds per acre of a single species
4. Seeding depth using a seed drill or broadcast seeder
5. Gaps in production: Early spring-summer, Midsummer-fall, Overwinter, Full season fallow, Intercrop, Perennial
6. Objectives ratings are based on Managing Cover Crops Profitably (SARE), Midwest Cover Crop Council (MCCC) Decision Tool, and recent research
7. Nematode management
8. Forage value: Low, Moderate, High
9. *Raphanus sativus* var. *oleiformis*, *R. s.* var. *longipinnatus*

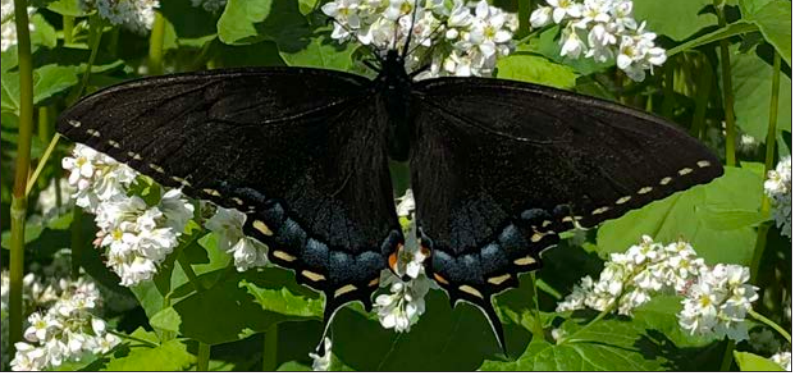

Figure 6—Upper Midwest insect visitors to cover crops (left to right): swallowtail butterfly on buckwheat[1]; bronze copper butterfly on phacelia[2]; jumping spider on sunflower[3]. (Photos: Naomy Candelaria[1]; Sarah Foltz Jordan / Xerces Society[2]; Sara Morris / Xerces Society[3].)

FORAGE VALUE[8]				
	WILD BEES	HONEY BEES	BENEFICIALS	INSECTS ATTRACTED | NOTES
	H	H	H	NATIVE BEES, HONEY BEES, BUTTERFLIES, SOLITARY WASPS, HOVERFLIES, LADY BEETLES, MINUTE PIRATE BUGS | Easy to establish; high value for beneficial insects
	M	M	M	NATIVE BEES, FLIES | Self-pollinated but visited by some insects; a good companion plant
	H	H	H	SWEAT BEES, BUMBLE BEES, HONEY BEES, HOVERFLIES | Bee magnet; difficult to establish in midseason if conditions are hot and dry
	H	H	H	MINUTE PIRATE BUGS, HONEY BEES, SOLITARY WASPS | Important pollen resource for native bees
N-fixers are established, legumes can move to background levels. Legumes vary in stature, shade- and traffic-tolerance, and challenging with this group, since soil N is generally maximized when termination occurs at or before flowering.				
	M	H	M	HONEY BEES, NATIVE BEES | Excellent for honey production and hay (although frequent cutting can reduce bloom availability)
	H	H	M	HONEY BEES | Blossoms lack a tripping mechanism making them more attractive to bees than some legumes
	H	H	H	SOLITARY WASPS, LADY BEETLES | Extrafloral nectaries (nectar-release sites on petioles and leaflets) attract beneficial insects
	H	H	M	WASPS, HOVERFLIES, HONEY BEES, NATIVE BEES | Abundant nectar for pollinators; grows well in the shade of other plants; excellent choice for underseeding
	H	M	H	BUMBLE BEES | Drought tolerant; typically fall seeded in this region for growth the next year; may be weedy/ invasive in some areas
	H	M	H	BUMBLE BEES, HONEY BEES, SOLITARY WASPS | Native to the Upper Midwest; extrafloral nectaries (nectar-release sites on petioles and leaflets) attract beneficial insects
	H	M	L	HIGH VALUE FOR BUMBLE BEES, MIGRATING MONARCHS | Nectar is most accessible to long-tongued insects; migrating monarchs often fuel up on nectar from this plant in the Fall
	H	M	M	BUMBLE BEES, LEAFCUTTER BEES | Good for biomass production; flower structure limits pollination to larger-stature bees
	H	H	M	HONEY BEES, SWEAT BEES, SMALL BUTTERFLIES | Dutch white is a common variety; very versatile plant
rooted and quick to establish, their acidic roots have less associations with mycorrhizal fungi. The potential to support flea				
	H	H	H	HOVERFLIES, HONEY BEES, NATIVE BEES | Nectar is attractive and easily accessible to bees. Can support flea beetle pests
	H	H	H	HOVERFLIES, HONEY BEES, NATIVE BEES | Nectar is attractive and easily accessible to bees. Can support flea beetle pests
	H	H	H	HOVERFLIES, HONEY BEES, NATIVE BEES | Nectar is attractive and easily accessible to bees. Can support flea beetle pests

Key:

- Life cycle—Annual, Perennial, Winter annual
- **FORAGE**—Pollinator forage
- **N** **NITROGEN** (source or scavenger)
- **FORAGE**—Livestock forage
- **COMP.**—Reduces compaction
- † In first season

Figure 7—Using a cultipacker after broadcast seeding (above) can help ensure cover crop seed mixes have adequate seed-to-soil contact for germination (below). (Photos: Sarah Foltz Jordan / Xerces Society.)

Planting Considerations

Site Preparation

Good site preparation is critical for cover crop establishment and weed suppression. Cultivating the seedbed immediately before seeding a cover crop can help reduce pressure from small weeds within the bed. In situations with high weed pressure, multiple passes of tillage staggered over a few weeks may be needed. Depending on weather conditions, irrigation post-seeding may be needed for good germination and growth. Cover crops may be established by broadcasting seed and lightly incorporating it; however, larger-seeded species will establish better if drilled. In either scenario, but especially when broadcasting, it can be helpful to follow seed dispersal with a cultipacker to ensure adequate seed-to-soil contact.

Seeding Rates

Seeding rates will vary depending on planting techniques and weed conditions. **Table 1—Select Blooming Cover Crops** provides suggested seeding rates based on existing resources and trials on Upper Midwest vegetable farms. These rates are sometimes higher than the minimum seed rates recommendations from suppliers, but produce farms that rely on tillage often have higher annual weed pressure than conventional row crop farms, and the higher cover crop rates suggested here should ensure successful stands that also suppress some weeds. The rate recommendations in Table 1 are for drilled seeds planted in monocultures; you may wish to increase the seeding rates by approximately 1.5× if broadcast seeding, and reduce the individual species rates somewhat when planting a species in a mix rather than monoculture.

Termination Techniques

Although termination of a cover crop is the last management step, techniques and timing should be one of the first steps in the planning process. There are many ways to terminate cover crops, including frost/winter kill, grazing/haying for livestock forage, or mechanical methods such as tillage. For maximum benefit to pollinators, cover crops should be allowed to achieve peak bloom prior to termination. If nesting habitat for pollinators is also a concern, termination methods that limit soil disturbance should be prioritized, such as mowing, crimping, and winter kill termination. Leaving surface residue of cover crops and utilizing reduced tillage techniques will increase beneficial insect habitat and improve soil health.

Cover Crops Are Only Part of the Solution for Pollinators

When it comes to native pollinator conservation, flowering cover crops should be recognized as a habitat **supplement**, not the whole story. This is because while flowering cover crops can provide important food resources for **generalist** pollinators, many pollinators are **specialists**, having very narrow feeding requirements. Typically, these specialists depend on **native plants** to meet their dietary requirements, particularly in the larval stage. Monarch butterfly (*Danaus plexippus*) adults, for example, will nectar on a variety of flowers (including some cover crops), but the caterpillars feed exclusively on the leaves of native milkweed (*Asclepias* spp.) in our region. About 30% of the ~1,800 bees native to the Central United States are considered specialists, only collecting pollen from certain native plant families or genera to feed their larvae. Another limitation of cover crops as pollinator habitat relates to the soil disturbance often involved in the process of establishing or terminating the cover. Since about 70% of our native bees are ground-nesting, having set-aside areas with undisturbed soil is critical. **To fully support pollinators we recommend incorporating diverse perennial native habitat that provides bloom throughout the growing season, nesting habitat for both stem- and ground-nesting insects, and protection from pesticides.** See our **Resources** section for guidance.

What About Cover Crop Mixes?

While cover crop blends can offer many advantages, they also have challenges, as summarized below:

Advantages of Cover Crop Mixes

- **Cover crop mixes offer multiple services simultaneously**. While some species have root systems that prevent erosion, reduce compaction, or scavenge nutrients below ground, others might flower above ground, attracting natural enemies that prey on nearby crop pests. Plants from different families attract unique faunal associations that have co-evolved with similar plants in natural landscapes. This diversity of plants will continue to offer benefits as they break down, attracting different soil dwelling detritivores and making nutrients bioavailable at different rates for future crops.
- **A diverse mix is more resilient to drought, flooding, or other stressors, compared to a monoculture.** While a monoculture is uniformly vulnerable to extreme weather conditions, a diverse stand will likely have some winners and losers. Some plants will be protected in the shade of larger plants; some will have more robust root systems to withstand drought and inundation; others, like grasses, will rapidly spring back after disturbance because their growing points are protected at or near the soil surface.
- **With careful design, cover crop mixes have the potential to generate several successions of bloom in just one planting.** For example, in a mix that includes buckwheat and sunflowers, the buckwheat would bloom first, sometimes even self-seeding for a second bloom before the sunflowers finally bolt later in the season to bloom. Another way bloom succession can occur is if the first round of blooms (e.g., buckwheat) is mowed just prior to seed set, which allows a different component of the mix to receive more light and bloom next (e.g., understory clovers).

Challenges of Cover Crop Mixes

- **While mixes can achieve multiple goals, they are also more complex to design** such that all the desired functions are realized, and may be less predictable and economical than a monoculture planting. Selecting appropriate seeding rates of each mix component can be tricky, as some species are more aggressive and can dominate a mixed stand and limit growth of other desirable species. The key is to select species and rates that will complement each other in their growth habits, which can require some experimentation. Even when mixes are "optimized" for a particular site, they may perform differently from year to year with varying soil, nutrient, and moisture conditions.
- **Full-season cover crop mixes intended to offer continuous floral resources for pollinators can also create challenges with managing seed set**. Staggered bloom time means staggered seed production, and some cover crop species can be problematic weeds for subsequent crops if they are allowed to enter the seedbank in large quantities. To get around this, some farmers opt for diverse cover crop mixes that include species with similar phenologies; that is, all of the species realize their full potential simultaneously and are also terminated simultaneously before they set seed.
- **Cover crop mixes can sometimes require multiple planting techniques**. Large-seeded species may need to be drilled or incorporated into the seedbed, while small-seeded species prefer to be surface sown. Consequently, multiple passes on the same field may be needed.

Principles for Choosing a Cover Crop Mix to Support Beneficial Insects

- Determine your objectives.
- In important production fields, start with a simple mix to minimize variables and make it easier to keep track of what's working. Select higher diversity or experimental mixes for fields where you have a higher tolerance for weeds.
- Include at least a few blooming species, and ensure they are planted in a window that is long enough to actually achieve bloom.
- Choose cover crops from multiple families to accomplish multiple goals.
- Be mindful of cover crops in the same plant family as cash crops (e.g., brassica cover crops), as they can host pathogens and insect pests that may impact subsequent cash crops. Consider how your mixes will fit into the crop rotation, including whether subsequent crops will be direct-seeded or transplanted (for example, buckwheat in the seed bank would not likely be a problem for transplanted tomatoes, but could be a problem for direct-seeded carrots).
- Be observant; take note of cover crop performance, time to flower, insect visitation, and other variables that may help you better understand and refine your mix.

Sample Cover Crop Mixes for Pollinators & Other Beneficial Insects

All three mixes are designed for full season coverage, but each blend brings different benefits and challenges. Mix 1 and Mix 2 provide abundant, high-value flowering resources for pollinators, but some species (particularly buckwheat) may contribute to a weed legacy in subsequent production years. Mix 3 includes flowering legume species that have somewhat less value for pollinators, but are also less likely to create management problems in subsequent years as competitive weeds. These mixes are provided as a starting point for you to adjust as you see fit, for your various needs and goals.

Sample Mix 1: Diverse Pollinator Blend

This annual mix provides a succession of abundant floral resources throughout the growing season. Several plant families are represented, including brassicas. Given the relatively high seeding rate of these fast-establishing species, there should be good suppression of agronomic weeds; however, some species within the mix will flower and set seed, which may require management in subsequent production years.

Since seed size in the mix varies, ask for species to be packaged separately so that large seeds can be drilled or incorporated deeper, and small seeds can be broadcast. If all seed must be planted together, then it is probably best to incorporate seed into the soil no more than ¼ to ½ inch. Finally, be mindful of brassica plant pathogens and insect pests that might be attracted to this mix, e.g., flea beetles.

Sample Cover Crop Mixes Key

1. **RATE** = Suggested seeding rates (lbs/ac)
2. **% OF MIX** = by weight
3. **/ SQ. FT.** = seeds per square foot
4. **% MIX** = by **/SQ. FT.**

SPECIES	RATE[1]	% OF MIX[2]	/SQ. FT.[3]	% MIX[4]
Oat	15	24.2%	6.8	9.2%
Buckwheat	10	16.1%	4.7	6.4%
Sunflower	1.5	2.4%	0.3	0.4%
Flax	4	6.5%	7.4	10.1%
Cowpea	7.5	12.1%	0.6	0.8%
Forage pea	7.5	12.1%	0.3	0.4%
Crimson clover	4	6.5%	13.8	18.7%
Berseem clover	4	6.5%	19.0	25.8%
Phacelia	2	3.2%	10.8	14.6%
Canola/ rapeseed	1	1.6%	3.6	4.9%
Radish	2.5	4.0%	2.0	2.6%
Partridge pea	3	4.8%	4.5	6.1%
Totals	**62**	**100%**	**73.7**	**100%**

Figure 8—This field was planted with a Albert Lea Seeds' Pollinator Max cover crop mix- a blend that is very similar to Sample Mix 1, listed above. At the time of the photo in mid-August, there are at least five species in bloom, along with many species that have already flowered and set seed. There are also some agronomic weeds like foxtail that have been sheltered in the planting, and are contributing to the seedbank. Brassicas like rapeseed and radishes attract many beneficial insects such as hoverflies (right), as well as some pest insects like flea beetles (damage shown on center photo) (Photos: Dayna Burtness Nguyen / Nettle Valley Farm [left]; Karin Jokela / Xerces Society [center, right].)



Figure 9—This buckwheat, phacelia, sunflower blend was planted at a vegetable farm in Cannon Falls, MN, on May 15. Left to right: seedlings on June 12[1]; buckwheat and phacelia blooming on July 11[2]; close-up of a bumble bee on buckwheat[3]. (Photos: Karin Jokela / Xerces Society[1,2]; Sarah Foltz Jordan / Xerces Society[3].)

Sample Mix 2: High Value Pollinator Blend

This mix optimizes floral resources for pollinators throughout the growing season, but also has the highest potential for seed production that could be problematic for subsequent crops, since buckwheat (and any agronomic weeds that come up) will set seed as you are waiting for the sunflowers to grow and establish. When planting, the sunflowers and the buckwheat seed should be incorporated into the soil, while the phacelia is best surface sown.

SPECIES	RATE[1]	% OF MIX[2]	/SQ. FT.[3]	% MIX[4]
Buckwheat	25	67.6%	11.7	17.7%
Phacelia	10	27.0%	54.0	81.7%
Sunflower	2	5.4%	0.4	0.6%
Totals	**37**	**100%**	**66.1**	**100%**

Sample Mix 3: Diverse Clover Blend

This mix includes a variety of clovers with a nurse crop of oats and field peas. The oats and field peas are quick to establish, while the clovers are slower to develop biomass.

Once the oats and field peas begin to flower (~40–50 days post-seeding), they should be mowed down (flail mowing at 6–8" is best) to allow the clovers to grow and flower later in the season.

SPECIES	RATE[1]	% OF MIX[2]	/SQ. FT.[3]	% MIX[4]
Oat	30	39.5%	13.5	10.5%
Field pea	30	39.5%	3.4	2.7%
Red clover	2	2.6%	12.5	9.8%
White clover	2	2.6%	36.0	28.1%
Alsike clover	2	2.6%	23.0	18.0%
Berseem clover	4	5.3%	19.0	14.8%
Crimson clover	6	7.9%	20.6	16.1%
Totals	**76**	**100%**	**128**	**100%**

Figure 10—This diverse clover mix with oats was planted on a farm in southeast MN on May 6. The oats and peas established quickly, while the clovers were slower to put on biomass. The photo on the left was taken about 35 days after planting (mid-June). Bloom began about 85 days after planting (late August). (Photos: Karin Jokela / Xerces Society [left]; Sarah Foltz Jordan / Xerces Society [right].)


UMN Research Study: Beneficial Insects in Summer Cover Crops

This SARE-funded research project by the University of Minnesota—in collaboration with Big River Farms, the White Earth Nation Department of Agriculture, and the Xerces Society—examined the performance of warm-season flowering cover crops in organic vegetable systems.

Eight cover crop treatments (Table 2) were seeded in two rotational timeslots:

1. Early May, followed by a fall broccoli crop; and
2. June/July after harvest of an early spring lettuce crop.

In each time slot, the research team monitored the productivity of the cover crop treatments, their flowering periods, and their attractiveness to pollinators and other beneficial arthropods. The uptake and release of nutrients from cover crop biomass and their effects on the yields of subsequent vegetable crops were also measured.

Figure 11—Cover crops test plots blooming in early summer at Big River Farms in Marine on St. Croix, MN. Clockwise from top left: crimson clover, field pea & oat mix, blooming buckwheat, and blooming phacelia. (Photo: Sarah Foltz Jordan / Xerces Society.)

Table 2: Cover Crop Treatments

TREATMENT	SPECIES	🌱
Buckwheat	*Fagopyrum esculentum*	90
Phacelia	*Phacelia tanacetifolia*	12
Crimson clover	*Trifolium incarnatum*	34
Field pea / oat	*Pisum sativum* ssp. *arvense* / *Avena sativa*	105 / 94
Sunflower / oat	*Helianthus annuus* / *Avena sativa*	15 / 94
Weedy fallow*	*Amaranthus retroflexus*, *Chenopodium album*, *Setaria viridis*, others	N/A
Weed-free fallow	None	N/A

KEY: 🌱 Seeding rate = lb · ac^{-1} | * Dominant species included pigweed, lamb's quarters, foxtail

Figure 12—Cover crops test plots flowering in late Fall at White Earth Nation in Mahnomen, MN. Clockwise from top left: blooming sunflower/oats, blooming phacelia, and buckwheat going to seed. (Photo: Adria Fernandez.)

Figure 13—Predatory wasp visiting buckwheat in trial field. (Photo: Sarah Foltz Jordan / Xerces Society.)

Figure 14—Bumble bee (*Bombus* sp.) visiting phacelia in field trial. (Photo: Sarah Foltz Jordan / Xerces Society.)

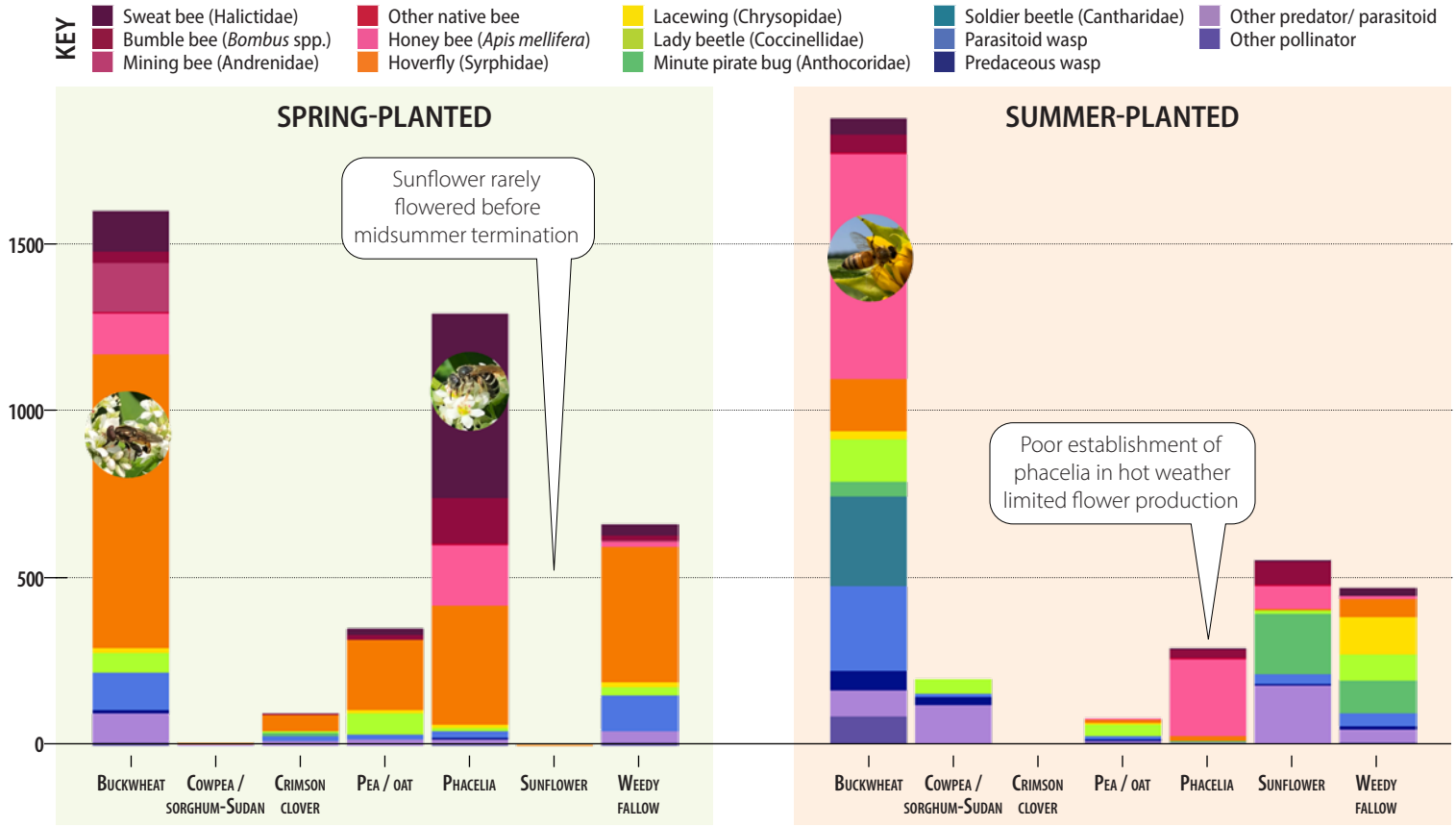

Figure 15—Insect visitation of flowering cover crops in research plots planted in early spring (left) and mid-summer (right) at Big River Farm (Marine on St. Croix, MN) and MN Agricultural Experiment Station (St. Paul, MN). Insect monitoring was conducted using non-lethal (observation-based) methods. Values represent total observations over the cover crop flowering period in the 2020 and 2021 seasons at both sites.

Beneficial Insect Results

Of all treatments, phacelia and buckwheat attracted the greatest abundance and diversity of beneficial arthropods. **Phacelia** was especially supportive of native bees, particularly small sweat bees (Halictidae). Phacelia was also highly attractive to hoverflies, particularly *Toxomerus marginatus*, a predator of agricultural pests in its larval stage; and minute pirate bugs, a predator of common agricultural pests such as aphids and thrips. **Buckwheat** supported abundant bees, and were most visited by honey bees when hives were present. In addition, buckwheat attracted a diversity of natural enemies of crop pests, including hoverflies, lady beetles, vespid wasps, and parasitic wasps. Buckwheat was the quickest cover crop to flower, beginning to bloom 34–39 days after planting, resulting in a relatively long bloom time. **Sunflower** was highly attractive to native bees and other beneficial insects when blooming, although its longer time to reach flowering meant that it did not consistently bloom in these time slots before being terminated or winter-killed. The leguminous cover crops, **crimson clover**, **field pea**, and **cowpea**, attracted fewer pollinators and overall fewer beneficial insects than the weedy fallow treatment. This may be explained by limited bloom of some of the covers, especially crimson clover & cowpea; limited attractiveness of legumes to some bees due to complex floral anatomy, and the presence of a variety of flowering weeds in the weedy fallow.

Cover Crop Performance

All of the cover crops established well from broadcast seeding both in early spring and in mid-summer, if sufficient moisture was available. Midsummer cover crop establishment was poor when conditions were extremely hot. Because sunflower was slow to establish, researchers found that undersowing with oats was helpful for filling space and excluding weeds during early growth. Although cover crops can build long-term soil fertility, summer-planted covers in this trial did not improve subsequent broccoli or lettuce crop yields, and sometimes caused yield reductions, possibly due to the short duration of the study, and the soil moisture demand by the cover crops during the study period.

In addition to planting replicated trials, this project provided seed to several farmers to plant test plots on their own farms. Several collaborators suggested that recommended seeding rates (Table 2) seemed low, and thought that stands would likely be more productive and less weedy if planted at higher rates. Instead of broadcasting the seed, one farmer achieved strong establishment of larger-seeded cowpea and sorghum-Sudangrass using a hand-pushed Earthway seeder, which results in subsurface seed placement similar to drilling.

Key Cover Crop Visitors Quick Reference

Figure 16—Above are some of the key groups of pollinators and beneficial insects that visit flowering cover crops, such as buckwheat[1,3,5,7,9], sunflower[2], cowpea[4], crimson clover[6], red clover[8], and phacelia[10]. Photos: Sarah Foltz Jordan / Xerces Society[1,3,5,7,9]; Nancy Lee Adamson / Xerces Society[4]; Thelma Heidel-Baker / Xerces Society[8]; Sara Morris / Xerces Society[2,10].

Resources

- *Cover Cropping for Pollinators and Beneficial Insects* | SARE & The Xerces Society
  xerces.org/sites/default/files/2018-05/15-054_01_SARE_Cover-Cropping-for-Pollinators%2BBeneficial-Insects_web.pdf
- Cover Crop Resources | SARE
  www.sare.org/resources/cover-crops/
- *Cover Crop Decision Tool* | Midwest Cover Crops Council
  midwestcovercrops.org/covercroptool/
- Tech Note 33: *Cover Crop Seeding Guide* | Minnesota NRCS
  efotg.sc.egov.usda.gov/api/CPSFile/392/340_MN_GD_Agronomy_Technical_Note_2018
- *Cover Crop Selection for Vegetable Growers* | University of Minnesota
  extension.umn.edu/cover-crops-and-soil-health/cover-crop-selection-vegetable-growers
- *Managing Cover Crops Profitably* | SARE
  www.sare.org/resources/managing-cover-crops-profitably-3rd-edition/
- Farming with Native Beneficial Insects | The Xerces Society
  www.xerces.org/publications/books/farming-with-native-beneficial-insects
- *Upper Midwest Community Science Pollinator Monitoring Guide: Native Bees* | The Xerces Society
  xerces.org/publications/id-monitoring/upper-midwest-citizen-scientist-pollinator-monitoring-guide-native
- Beneficial Insect Scouting Guides | The Xerces Society
  xerces.org/publications/scouting-guides

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